

Detection of ULF Analogy Using ACO Based Algorithm in Power Distribution Networks

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Abstract—Distribution and Transmission are two key systematic parameters in power systems engineering and power systems are places a huge role in nation's progress. Now a day's Power Distribution Networks are exaggerated by different tribulations like voltage dip conditions, harmonics, swell and sag conditions and faults etc. Out of mentioned, faults are very dangerous that affects voltage stability and load balancing phenomenon. The proposed article will able to explain the identification of Unbalanced Load Faults (ULF) using modern optimization techniques. This technique initiates the problem by taking number of iterations and contextual procedure i.e. Ant Colony Optimization (ACO). This is best methodology apt for any mechanical and electrical distribution networks helps to negotiate the problem by taking number of iterations. The proposed article suggests how to identify the unbalanced fault analogy and faults behavior using ACO based algorithm. The overall topology was investigated and simulated and highly graphical facilities are provided with help of MAT Lab Simulation.

Index Terms—unbalanced load faults (ULF), ant colony optimization (ACO), modern optimization technique, power distribution networks, fault searching behavior

I. INTRODUCTION

A Transmission line is one of the most important prototype parameter of power system which is used to synchronizing the transmission and distribution networks. Adequately, the transmission and distribution may have the losses and voltage abrupt conditions; faults too. Faults in the transmission line places a prominent role in the power systems. Ideally, due to the fault conditions the entire system may damages. In order to the faults besides there is a voltage dip conditions and different voltage fluctuations are occurring over there. In the entire power system, the transmission and distribution are main phenomenon systems [1]. Faults are occurring due to unavoidable fluctuations in voltage and currents and short circuit condition and internal losses in synchronous generators. These may avoided by maintaining the proper node and base voltages at terminal conditions. The

various types of faults occurring on a transmission line are: single line to ground faults, double line faults, double line to ground faults, triple line faults and triple line to ground faults. From the previous discursions, the fault can be modified by using different compensation devices and techniques [2]. The proposed technique we are using in this article is Anti colony, helps to detect the fault and modified. The partial part of detection and identification, modification was proved. Here the proposed article explains reference of fault detection using modern optimization technique. Mainly, the optimization techniques are classified as different types; they are Genetic algorithms, simulated annealing, Particle swarm optimization, Ant colony optimization, Fuzzy optimization, and Neural-network-based methods. Most of these methods have been developed only in recent years and are emerging as popular methods for the solution of complex engineering problems. Most require only the function values (and not the derivatives). The genetic algorithms are based on the principles of natural genetics and natural selection [3]. Simulated annealing is based on the simulation of thermal annealing of critically heated solids. Both genetic algorithms and simulated annealing are stochastic methods that can find the global minimum with a high probability and are naturally applicable for the solution of discrete optimization problems [4]. The particle swarm optimization is based on the behavior of a colony of living things, such as a swarm of insects, a flock of birds, or a school of fish. Ant colony optimization is based on the cooperative behavior of real ant colonies, which are able to find the shortest path from their nest to a food source. In many practical systems, the objective function, constraints, and the design data are known only in vague and linguistic terms. Fuzzy optimization methods have been developed for solving such problems. In neural-network-based methods, the problem is modeled as a network consisting of several neurons, and the network is trained suitably to solve the optimization problem efficiently. Out of all these we are implementing ACO Technique for pre and post fault identification and detection [5]. The ant colony helps to check the fault as a multi variable processing. The proposed algorithm was designed and considered fault as

ant and food as a power system. Here the same phenomenon is applied for obtain the pre and post fault detection. This article only will explain the fault detection and identification by using multi variable approach.

II. OVER VIEW OF POWER DISTRIBUTION NETWORK- TESTING OF POWER SYSTEM MODEL

The test power system consists of two equal distant 320kV parallel lines having 50kms length. The two lines are feed from generators G1 and G2 respectively as represented in the block diagram itself. The both line models are distributed type and used for power distribution from source to user end. Manually, the lines are initiated and transposed by R, L, C parameters. They are compressed with positive and zero sequence faults. The source end was designated by a transformer and load end too. Here the fault was created in any one of the lines are creates the disturbance and telephonic interference in the lines are nothing but harmonics and are due to fault conditions [6]. The Fig. 1 Shows power distribution network model represents a source and load end with probable fault. The proposed power system model resembles the test system used for fault identification which is crested in any one of the two parallel lines itself.

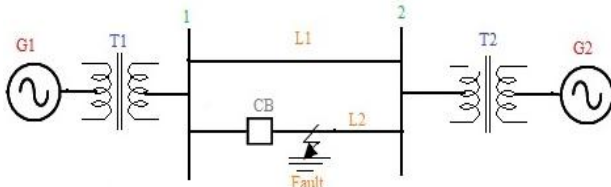


Figure 1. Tested power distribution network model

III. FAULT DETECTION USING ACO IN POWER DISTRIBUTION NETWORKS

ACO is super imposed genetic algorithm based methodology. The proposed paper describes the search the fault in power system like an ant searching for food. The proposed article explains the comparison of fault occurrence with ant's propagation. Here the fault was compared with insect ant and the material food was compared against with test power syatem. Fig. 2 initiates the pre-fault and post-fault data identification using ACO Methodology [7].

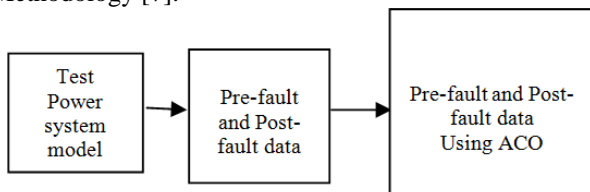


Figure 2. Fault identification using ACO

IV. ANT COLONY OPTIMIZATION FOR FAULT DETECTION

Ant colony optimization (ACO) is based on the cooperative behavior of real Fault colonies, which are able to find the shortest path from their nest to a Modified

source. The Fault colony optimization process can be explained by representing the optimization problem as a multilayered graph, in that Fault conditions are replaced by faults and Modified source is test system. Where the number of layers is equal to the number of design variables and the number of nodes in a particular layer is equal to the number of discrete values permitted for the corresponding design variable. Thus each node is associated with a permissible discrete value of a design variable. Fig. 3 denotes a problem with six design variables with eight permissible discrete values for each design variable, The ACO process can be explained as follows. Let the colony consist of N Faults.

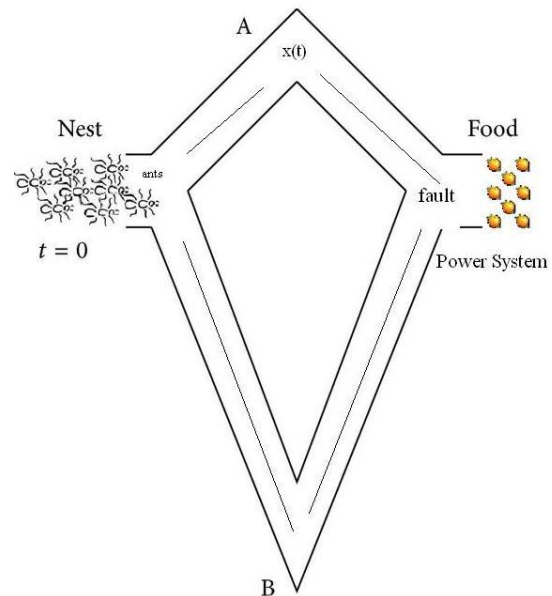


Figure 3. Fault based single layer ACO network

The Faults start at the home node, travel through the various layers from the first layer to the last or final layer, and end at the destination node in each cycle or iteration. Each Fault can select only one node in each layer in accordance with the state transition rule given by Equation (1). The nodes selected along the path visited by a Fault represent a candidate solution. For example, a typical path visited by a Fault is shown by thick lines in Fig. 1. This path represents the solution (x_{12} , x_{23} , x_{31} , x_{45} , x_{56} , and x_{64}) [8]. Once the path is complete, the Fault deposits some pheromone on the path based on the local updating rule given by Equation (3). When all the Faults complete their paths, the pheromones on the globally best path are updated using the global updating rule described by Equations (1) and (2). In the beginning of the optimization process (i.e., in iteration 1), all the edges or rays are initialized with an equal amount of pheromone. The optimization process is terminated if either the pre specified maximum number of iterations is reached or no better solution is found in a pre specified number of successive cycles or iterations. The values of the design variables denoted by the nodes on the path with largest amount of pheromone are considered as the components of the optimum solution vector [9]. In general, at the optimum solution, all Faults travel along the same best (converged) path.

A. Fault Searching Behavior

A Fault k , when located at node i , uses the pheromone trail τ_{ij} to compute the probability of choosing j as the next node

$$P_{ij}^{(K)} = \begin{cases} \frac{\tau_{ij}^\alpha}{\sum_{j \in N_i^{(K)}} \tau_{ij}^\alpha} & \text{if } j \in N_i^{(K)} \\ 0 & \text{if } j \notin N_i^{(K)} \end{cases} \quad (1)$$

where α denotes the degree of importance of the pheromones and $N_i^{(K)}$ indicates the set of neighborhood nodes of Fault k when located at objective i . Then beside of all objectives i contain all the nodes directly connected to node i accept the predecessor node (i.e., the last node visited before i). This will prevent the Fault from returning to the same node visited immediately before node i . A Fault travels from node to node until it reaches the destination (Modified) node is updated as follows

$$\tau_{ij} \leftarrow \tau_{ij} + \Delta\tau^{(K)} \quad (2)$$

Due to the incremental changes in the proto type phenomenon, the critical nature of this arc being selected by the forthcoming Fault condition will increase.

B. Pheromone Trail Evaporation for Fault Detection

When a Fault k moves to the next node, the pheromone evaporates from all the arcs ij according to the relation

$$\tau_{ij} \leftarrow (1-p) \tau_{ij}; \forall (i, j) \in A \quad (3)$$

where $p \in (0, 1]$ is a parameter and A denotes the segments or arcs traveled by Fault k in its path from home to destination. The decrease in pheromone intensity favors the exploration of different paths during the search process. This favors the elimination of poor choices made in the path selection. This also helps in bounding the maximum value attained by the critical procedure. A step is process of a complete description of Fault's movement, pheromone evaporation and pheromone deposit. After all the Faults return to the home node (nest), the pheromone information is updated according to the relation

$$\tau_{ij} = (1-p) \tau_{ij} + \sum_{K=1}^N \Delta\tau_{ij}^{(K)} \quad (4)$$

where $p \in (0, 1]$ is the evaporation rate (also known as the pheromone decay factor) and τ_{ij} is the amount of pheromone deposited on arc ij by the best Fault k . The goal of pheromone update is to increase the pheromone value associated with good or promising paths [10]. The pheromone deposited on arc ij by the best Fault is taken as

$$\Delta\tau_{ij}^{(K)} = Q/L_K \quad (5)$$

where Q is a const Fault and L_k is the length of the path traveled by the k^{th} Fault (in the case of the travel from one city to another in a traveling salesman problem). Equation (5) can be implemented as

$$\Delta\tau_{ij}^{(K)} = \begin{cases} \frac{Q}{f_{best}}; & \text{if } (i, j) \in \text{global best tour} \\ 0; & \text{other wise} \end{cases} \quad (6)$$

where f_{worst} is the worst value and f_{best} is the best value of the objective function among the paths taken by the N Faults, and ζ is a parameter used to control the scale of the global updating of the pheromone. The larger the value of ζ , the more pheromone deposited on the global best path, and the better the exploitation ability [9]. The aim of Equation (5) is to provide a greater amount of pheromone to the tours (solutions) with better objective function values.

V. PRAPOSED ALGORITHM FOR FAULT DETECTION

The orientational procedure of ACO algorithm for solving a minimization problem can be summarized as follows

Step 1

Assume a suitable number of Faults in the colony (N). Assume a set of permissible discrete values for each of the n design variables. Denote the permissible discrete values of the design variable x_i as $x_{i1}, x_{i2}, \dots, x_{ip}$ and ($i=1, 2, \dots, n$). Assume equal amounts of pheromone $\tau_{ij}^{(1)}$ initially along all the arcs or rays (discrete values of design variables) of the multilayered graph shown. The superscript to τ_{ij} denotes the iteration number.

For simplicity, $\tau_{ij}^{(1)}$ can be assumed for all arcs ij . Set the iteration number $l = 1$

Step 2

(a) Compute the probability (p_{ij}) of selecting the arc or ray (or the discrete value) x_{ij} as

$$p_{ij} = \tau_{ij}^{(l)} / \sum_{m=1}^p \tau_{im}^{(l)}; I=1, 2, \dots, n; j=1, 2, \dots, p \quad (7)$$

Which can be seen to be same as Equation (1) with $\alpha=1$. A larger value can also be used for α .

(b) The specific path (or discrete values) chosen by the k^{th} Fault can be determined using random numbers generated in the range (0, 1). For this, we find the cumulative probability ranges associated with different paths of Fig. 1 based on the probabilities given by Equation (7). The specific path chosen by Fault k will be determined using the roulette-wheel selection process in step 3(a).

Step 3

(a) Generate N random numbers r_1, r_2, \dots, r_N in the range (0, 1), and one for each Fault. Determine the discrete value or path assumed by Fault k for variable i as the one for which the cumulative probability range [found in step 2(b)] includes the value r_i .

(b) Repeat step 3(a) for all design variables $i=1, 2, \dots, n$.

(c) Evaluate the objective function values corresponding to the complete paths (design vectors $X^{(k)}$ or values of x_{ij} chosen for all design variables as $i=1, 2, \dots, n$ by Fault $k, k=1, 2, \dots, N$) is

$$F_k = f(X^{(k)}); k=1, 2, \dots, N \quad (8)$$

To obtain the better and worst paths chosen by different Faults are

$$F_{best} = K = 1, 2, 3^{\min}, \dots, N^{\{f_k\}} \quad (9)$$

$$F_{best} = K = 1, 2, 3^{\max}, \dots, N^{\{f_k\}} \quad (10)$$

Step 4

Test for the convergence of the process. The process is assumed to have converged if all N Faults take the same best path. If convergence is not achieved, assume that all the Faults return home and start again in search of Test Power System. Set the new iteration number as $l = l+1$, and update the pheromones on different arcs (or discrete values of design variables) as

$$\tau_{ij}^{(l)} = \tau_{ij}^{(old)} + \sum_k \Delta\tau_{ij}^{(k)} \quad (11)$$

where $\tau_{ij}^{(old)}$ denotes the pheromone amount of the previous iteration left beyond the convergent process, which is written as

$$\tau_{ij}^{(old)} = (1-\rho) \tau_{ij}^{(l-1)} \quad (12)$$

and $\Delta\tau_{ij}^{(k)}$ is the pheromone deposited by the best Fault k on its path and the Summation extends over all the best Faults k (if multiple Faults take the same best path). Note that the best path involves only one arc ij (out of p possible arcs) for the design variable i . The evaporation rate or pheromone decay factor ρ is assumed to be in the range 0.5 to 0.8 and the pheromone deposited is $\Delta\tau_{ij}^{(k)}$ computed using Equation (6).

With the new values of $\Delta\tau_{ij}^{(l)}$, go to step 2. Steps 2, 3, and 4 are repeated until the process converges, that is, until all the Faults choose the same best path. In some cases, the iterative process is stopped after completing a pre-specified Maximum number of iterations (l_{max}).

VI. RESULTS AND DISCURSIONS FOR TEST SYSTEM

The proposed test system contains identification of pre-fault and post-faults on distribution networks. The proposed algorithm can be used for observing the most common fault in power distribution network i.e. L-G Fault. Fig. 5 Represents performance of test power system during the fault condition, initiates that fault current on y-axis and impedance on x-axis respectively. If we observe the Fig. 5 fault represents seven number of iterations are over there.

The pre-fault and post fault are observed by using ACO based algorithm. In, Fig. 5 utmost of 7 cycles are assembled are first cycle initiates starting node point of fault current i.e. pre-fault and the next sixth cycle initiates maximum probability of fault current of test system in power distribution networks.

The test system fed by unbalanced load in abnormal conditions and faults are represented with number of iterations. Each of iteration resembles the portion of fault in working conditions. The Fig. 5 represents seven number of cycles are nothing but faults. So, during unbalanced load conditions the test system able to show the more number of iteration without any optimization or additive complex technique applied over there.

In Fig. 4, on x axis fault impedance and y-axis fault current was represented. Fig. 4 represents the performance characteristics of ACO based algorithm during unbalanced L-G fault on the distribution network during abnormal condition, having less number of iterations as compared to the performance Characteristics of Fig. 5 having without any control tool, however the

overall topology of the proposed system can only be done with ACO optimization method such that the performance characteristics shows that better performance during any un-desirable or abnormal conditions also.

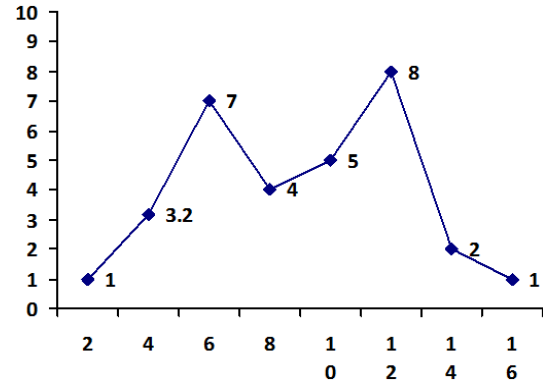


Figure 4. Test system during fault condition

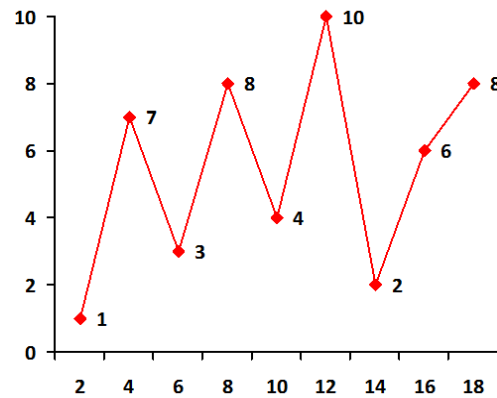


Figure 5. Implementation of ACO based algorithm for test system

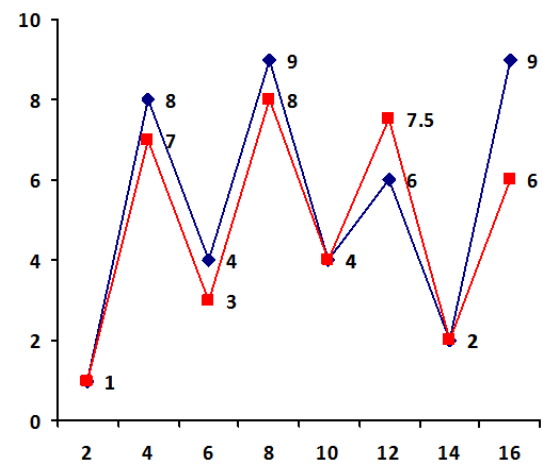


Figure 6. Comparison of fault occurrence in test system, with and without AC optimization

In Fig. 6, on x axis fault impedance and y-axis fault current was represented. Fig. 6 shows that the comparison between performance characteristics of the test system during with control and without control in the above graphical representation Red graphical representation indicates that performance characteristics with any controlling method during abnormal conditions but Blue colour graphical representation clearly indicates that

better performance as compared to conventional un-control modeled characteristics.

VII. CONCLUSIONS

The paper presents pre-determination and identification of fault using Ant Colony Optimization. The proposed topology explains the most dangerous faults scenario described as an Unbalanced Load Fault Analogy. Here the fault is characterized by the insect ant, and the power system initiated as a material food itself.

The evaluated simulation are explains comparison of fault variations with source and destination of ant.

If more iteration is over there in ACO, then the power system is affected by more. If there over less, the power system affects less. The overall topology was conducted for a proposed test system. Hence the ACO based algorithm helps to find or identify the most dangerous fault scenario in PDN. The entire topology was modeled and simulated, investigated. The high graphical representations are mentioned with help of MATLAB/Simulink.

APPENDIX

TABLE I. ILLUSTRATION FOR FAULT ANALOGY USING ACO BASED ALGORITHM

S.NO	Characterization of Single Line-Ground Fault				
	Number of Harmonic Spectrum	Fault Resistance	Voltage Sag	Voltage Swell	Harmonic Distortion
	in sequence order	R_f in Ω	P.U	P.U	in %
1	1st	0.66	0.8259	0.698	100
2	3rd	0.76	0.9867	0.7	47.22
3	5th	0.86	0.8634	0.567	67.9
4	7th	0.96	0.9645	0.4	45.67
5	9th	1.06	0.9143	0.55	56.45
6	11th	1.2	0.9472	0.53	34.67
7	13th	1.8	0.9316	0.23	89.67
8	15th	2.02	0.9531	0.5744	56.33
9	17th	2.08	0.9713	0.9	63.4
10	THD	0.3	0.9241	0.22	48.3
11	Power Factor of Load	0.2	0.9376	0.89	100

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